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APPROVED BY DRAFTSMAN

O.G. FIG.
CLASS | SUBCLASS

135a

110b

135b

Computing Device 110c

Computing Device 110a

Computing Device

Computing Device 110d

135c

14

Communications Network

Computing Device 110e

FIG. 1

10b

135d

135e

10a

Server

Server

Database 20

Playlist Generator 250

Classified Songs 240

Automated Classification 220

Human Classification 230

Songs 210

Fig. 2

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Fig. 3

Fig. 4A

ME ? +

CH11, CH12, CH13, ... , CH1N
CH21, CH22, CH23, ... , CH2N
⋮
CHM1, CHM2, CHM3, ... ,CHMN

+ Expert =

ME { CH13, CH21, ⋮, CHM7 }

Fig. 4B

ME ? +

CC11, CC12, CC13, ... , CC1N
CC21, CC22, CC23, ... , CC2N
⋮
CCM1, CCM2, CCM3, ... ,CCMN

+ DSP =

ME { CC11, CC25, ⋮, CCM2 }

Fig. 4C

ME = CH13, CH21, ..., CHM7, CC11, CC25, ..., CCM2 → Vector V_{ME}

Fig. 4D

Neighborhood — d_nh — EV1

Fig. 5A

**Classification Chain
Input Space IS**

CCV8 d8 $\quad$ d7 CCV7

CCV1

EV2

d1

EV1

d6

d2   d3

CCV6

CCV2   CCV3

d9

CCV4

d4

CCV9

CCV5   d5   EV2

Fig. 5B

error

e4

e3

e2

e1

d6   d1   d4   **distance of nearest
neighbor for each of
EV1, EV2 and EV3**

d_nh

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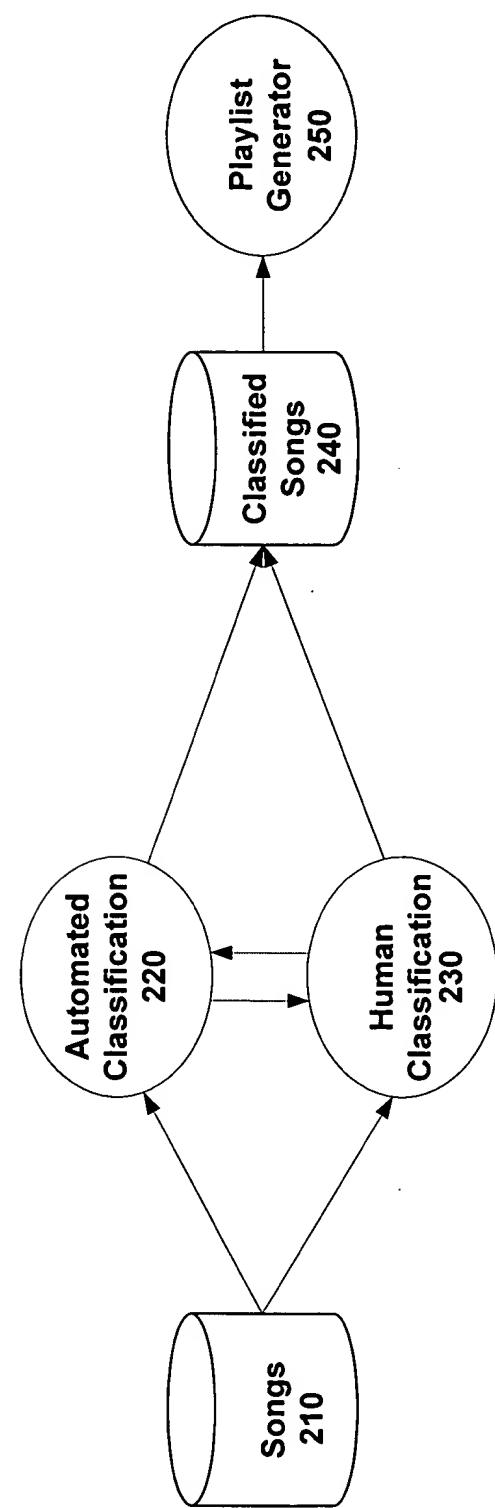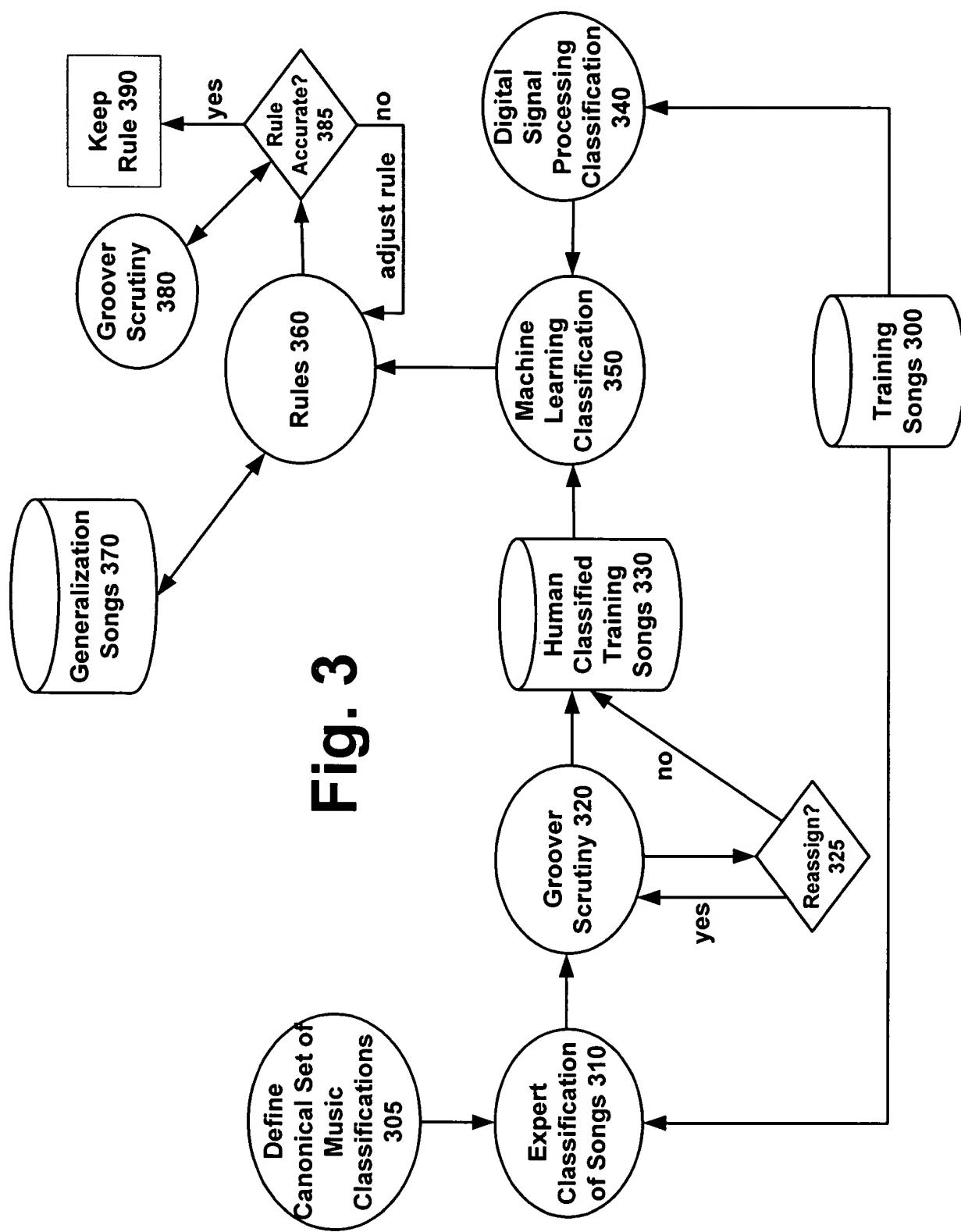Property Classification
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Fig. 6A

Classification Chain
Input Space IS

Fig. 6B

Classification Chain
Input Space IS

600
Start with the First Song of a Plurality of Unclassified Songs

605
Is Song Already in Database?

YES →

610
Is Training Complete?

NO →

615
Next Song of Plurality of Unclassified Songs

NO ↓ (from 605)

620
Calculate and Present Song Vector to Classification Chain

YES ↓ (from 610)

625
Quit

630
Calculate Response of Classification Chain

Fig. 6C

635
Is there a High Level of Confidence for Chain Output?

NO →

640
Expert Classifies Song, and Song Vector Added to Classification Chain

YES ↓

645
Next Song of Plurality of Unclassified Songs

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Fig. 7A

745
FFT

750
Critical Band Filtering

755
Entropy

760
Derivative

765
Average of All Frames

770
Feature Vector

775
Principal Component Analysis

780
Classification Chain

Fig. 7B

High

Sad ← → Happy

Emotion

Low

Mood

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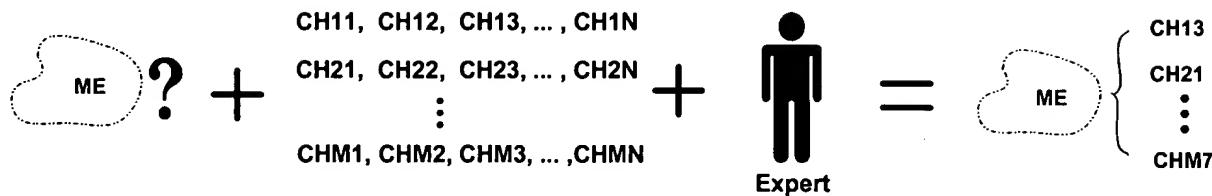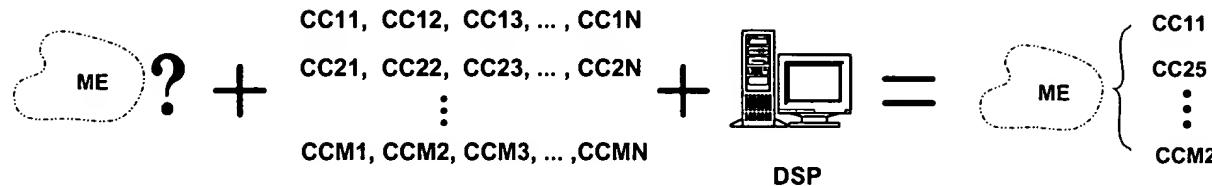Property Classification
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Fig. 8A

800

FFT

↓

802

Peak Detection

↓

804

Critical Band Filtering

↓

806

Peak Continuation

↓

808

Consonance Calculation

↓

810

Feature Vector

↓

812

Principal Component Analysis

↓

814

Classification Chain

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Fig. 8B

816

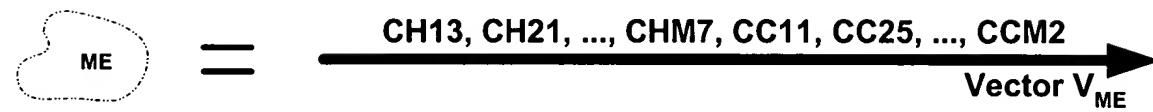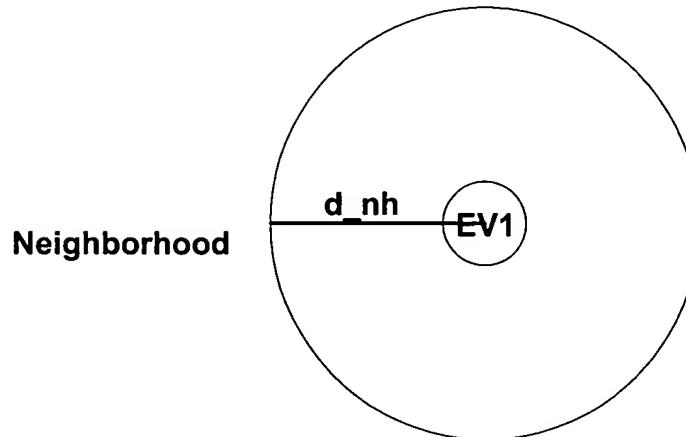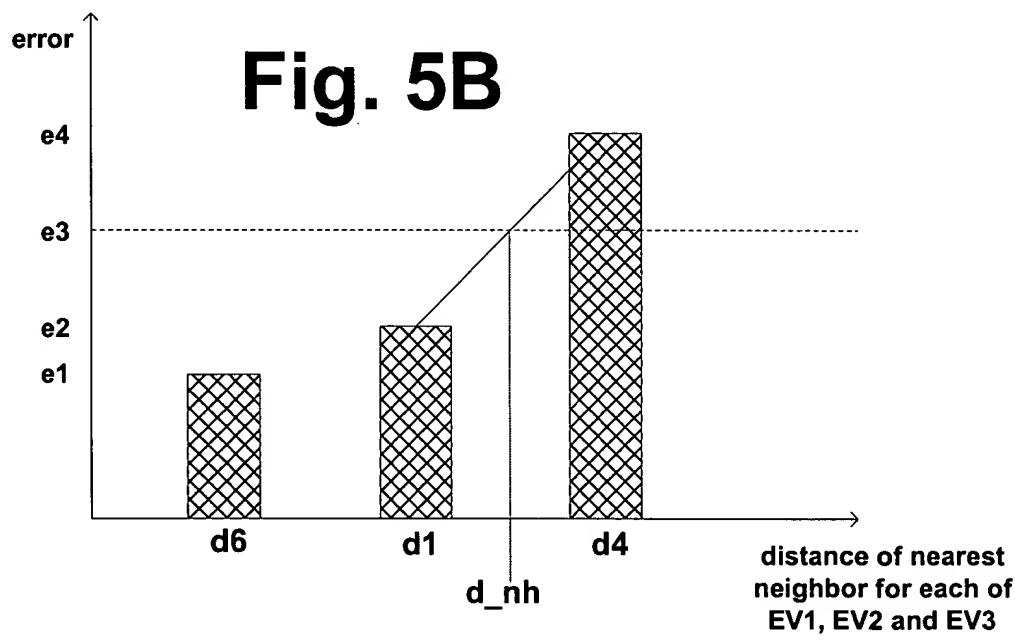FrameNum = 1 : NumFrames

818

Zero-pad and Take
FFT of Audio Frame

820

Diff_FFT[ ] = Successive
Differences of FFT'd
Buffer

822

FFTIndex =
1:NumBins

824

Diff_FFT(FFTIndex) > 0? — NO

YES

826

Diff_FFT(FFTIndex+1) < 0? — NO

YES

828

Record Bin &
Energy into
Output Matrices

830

FFTIndex++
FFTIndex >= LastBin?

NO

YES

834

Select Top
Requested Number
of Peaks

836

PeakNum = 1: NumPeaksRequested

838

Nth Order Interpolate Peaks'
Positions and Heights

840

PeakNum++
PeakNum > NumPeaksRequested? — NO

YES

842

FrameNum++
FrameNum > NumFrames? — NO

YES

844

FINISHED

846
Setup Guides Based on Peaks
in First Frame

848
For FrameNum = 1: NumFrames

850
PeakMatched = [ ]
GuideMatch = 0

852
For PeakNum = 1:NumPeaks

854
MinDiff = kNyquistFreq
Matched = 0
ThisPeak = Bins(FrameNum, PeakNum)
ThisEnergy = Energies(FrameNum, PeakNum)

856
For GuideNum = 1:NumGuides

858
ThisGuide = GuideFreq(GuideNum)
ThisGuideEnergy = GuideEnergy(GuideNum)

860
If ((ThisPeak
Is within 1/2 Step of ThisGuide)
& (PeakEnergy is within 6dB of
ThisGuideEnergy) & (ThisGuide
not Just Continued))

YES

862
GuideMatch = GuideNum
(Record Matched Guide #)

864
guideNum++
(guideNum>numGuides)?

NO

YES

866
GuideMatch != 0

NO

YES

868
- Record this Peak & Energy into Output
Matrix
- Record Possible Missed Peak in
Previous Frame if ThisGuide Just Started
- PeakMatched(PeakNum) = 1
- GuideState(GuideNum) = kContinued
- GuideEnergy(GuideNum) = ThisEnergy

870
PeakNum++
PeakNum > NumPeaks?

NO

YES

872
- Locate & Record Unused Guides
and Unmatched Peaks

874
Any Unused Guides
or Unmatched Peaks?

NO

YES

876
Start New Guides at the
Unmatched Peaks with Largest
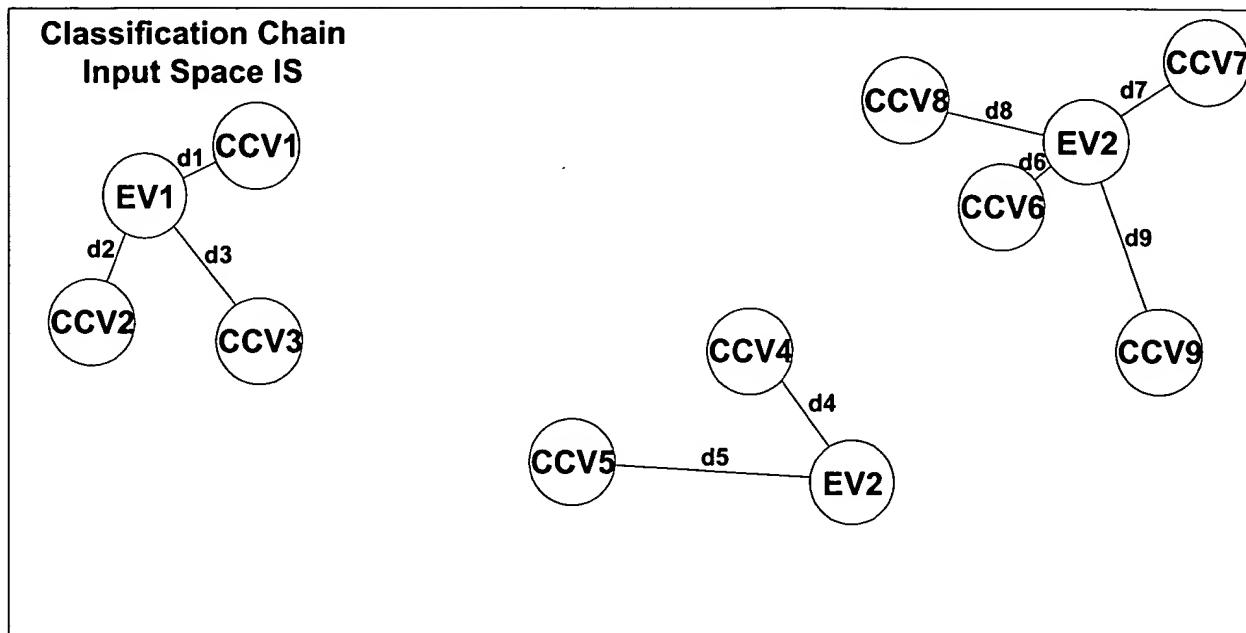Energy

878
FrameNum++
FrameNum > NumFrames?

NO

YES

879
FINISHED

Fig. 8C

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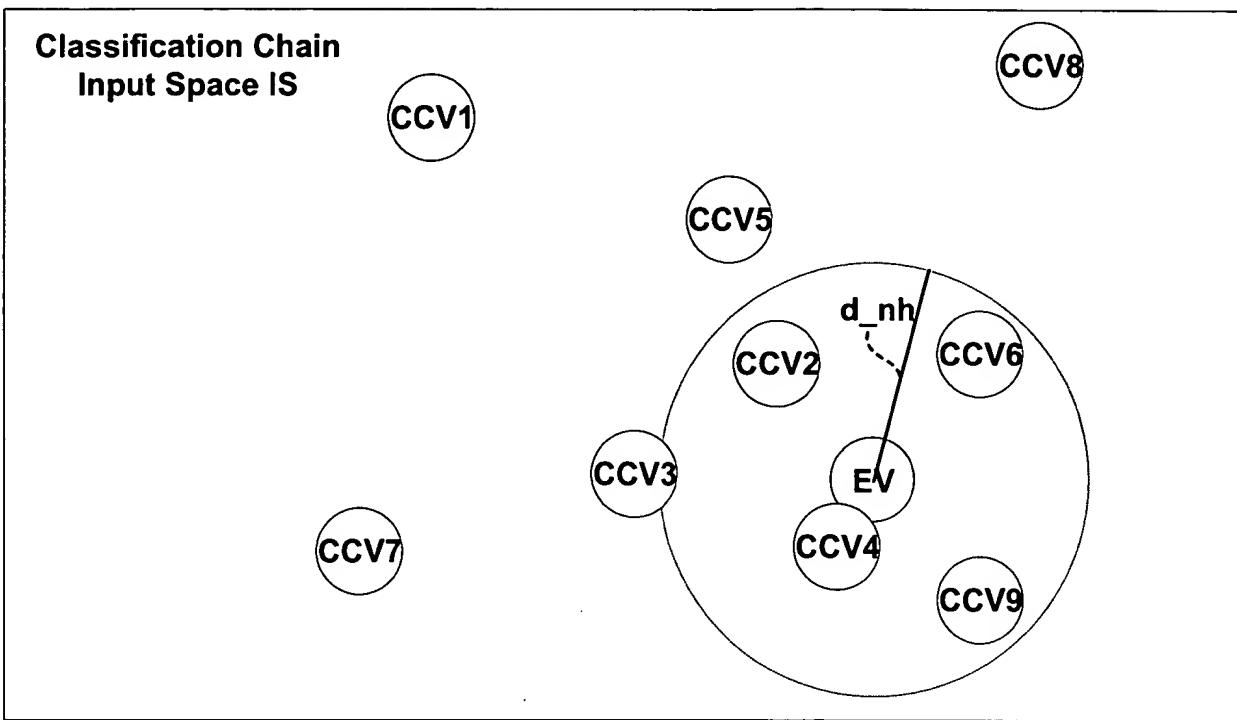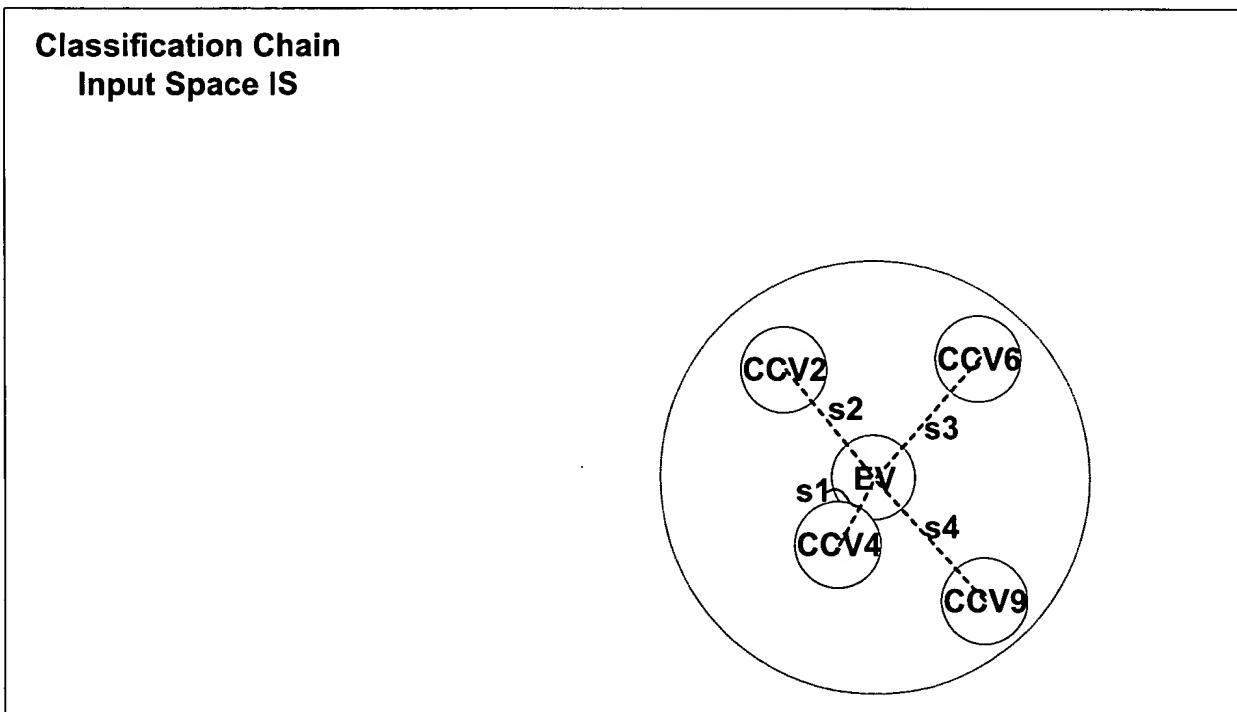Property Classification
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Fig. 8D

880 FrameNum = 1 : NumFrames

882 PeakBottom = 1 : NumPeaks

884 Denom = Peak_Locations(FrameNum, PeakBottom)

886 Denom != 0? — NO

YES

888 PeakTop = 1 : NumPeaks

890 Numer = Peak_Locations(FrameNum, peakTop)

892 Numer != 0? — NO

YES

894 Ratio = Nearest_Integer [12* log2 (Numer/Denom)]

896 Is (0<Ratio<25) — NO

YES

898 Increment Intervals(Ratio) Array by (Energies(FrameNum, PeakBottom))^2 and (Energies(FrameNum, PeakTop))^2

900 PeakTop++ PeakTop > NumPeaks? — NO

YES

902 PeakBottom++ PeakBottom > NumPeaks? — NO

YES

904 FrameNum++ FrameNum > NumFrames? — NO

YES

906 Interval = Interval / NumFrames (Take the Mean)

908 Normalize Interval Vector

910 FINISHED

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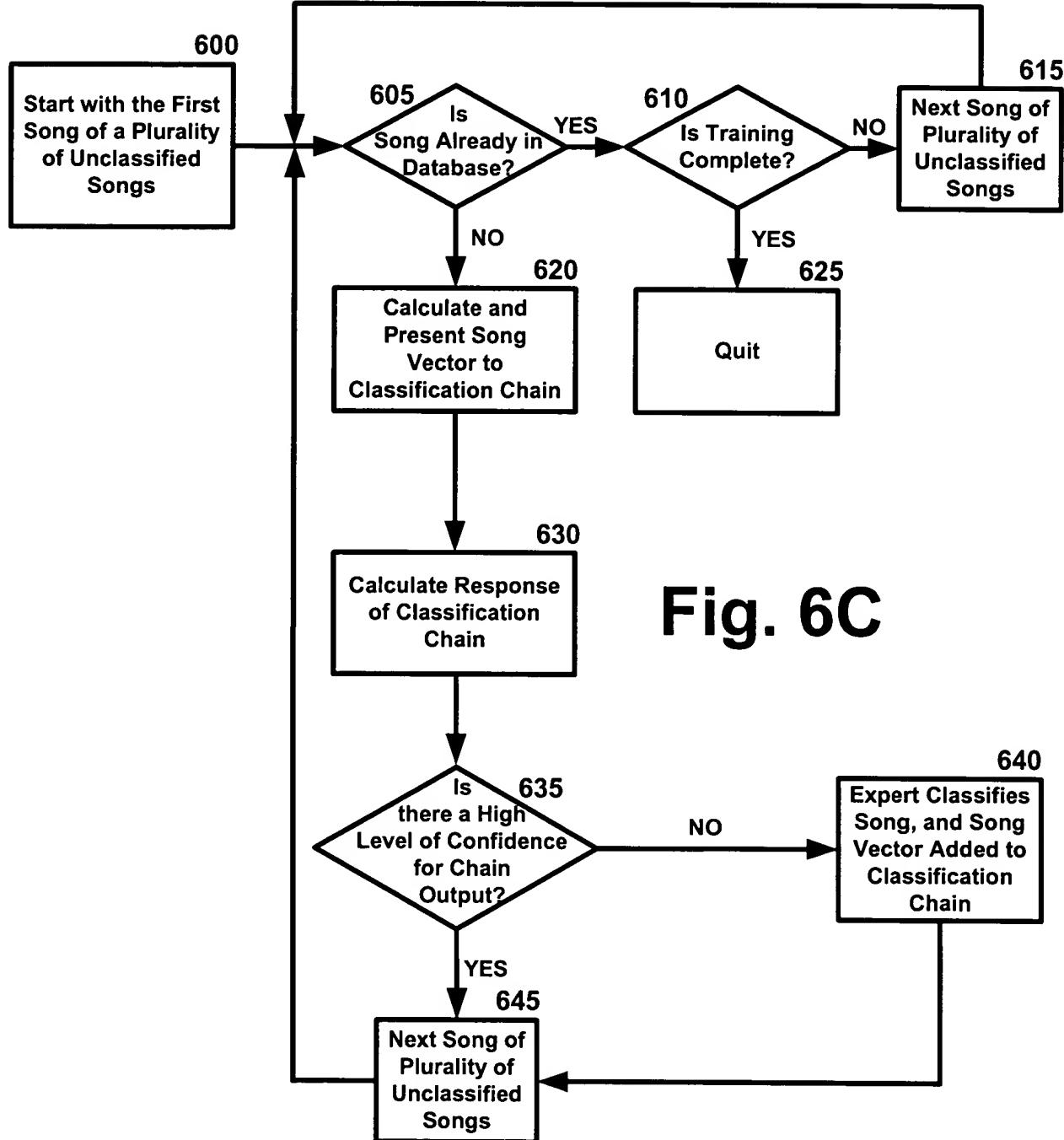Page 13 of 15

Fig. 9A

900

FFT

905

Peak Detection

910

Critical Band Filtering

915

Peak Continuation

920

Melodic Movement Calculation

925

Feature Vector

930

Principal Component Analysis

935

Classification Chain

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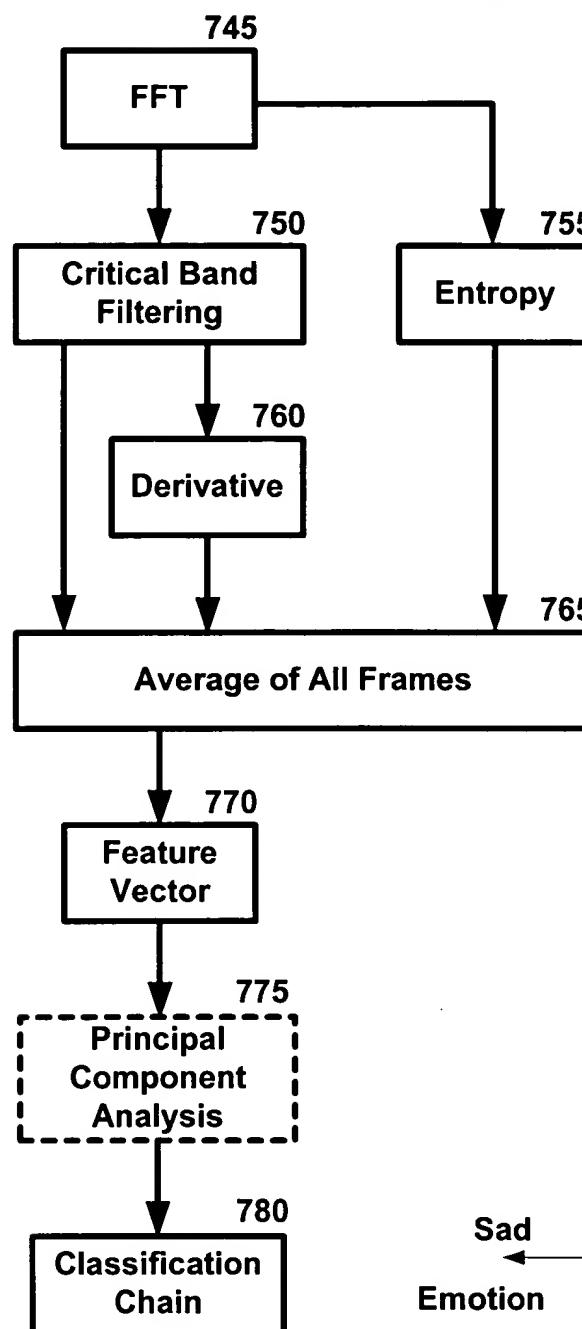Property Classification
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940

FrameNum = 1 : NumFrames

945

PeakNum = 1:numPeaks

950

Numer = Peak_Locations(FrameNum, PeakNum)

955

If (kFreqMin <= Numer <= kFreqMax) — NO

960

PitchClass = round(24*log2(Numer/ kFreqMin) - floor(log2(Numer/kFreqMin))

965

Is (0<PitchClass<25) — NO

YES

970

Melodic(FrameNum, PitchClass) = Melodic(FrameNum, PitchClass) + (Energies(FrameNum, PeakNum))

YES

975

PeakNum++
PeakNum > NumPeaks? — NO

980

FrameNum++
FrameNum > NumFrames? — NO

985

Melodic = Diff(Melodic)
(Take the 1st Difference)

990

Melodic = std(Melodic)
(Take Standard Deviation)

995

FINISHED

Fig. 9B

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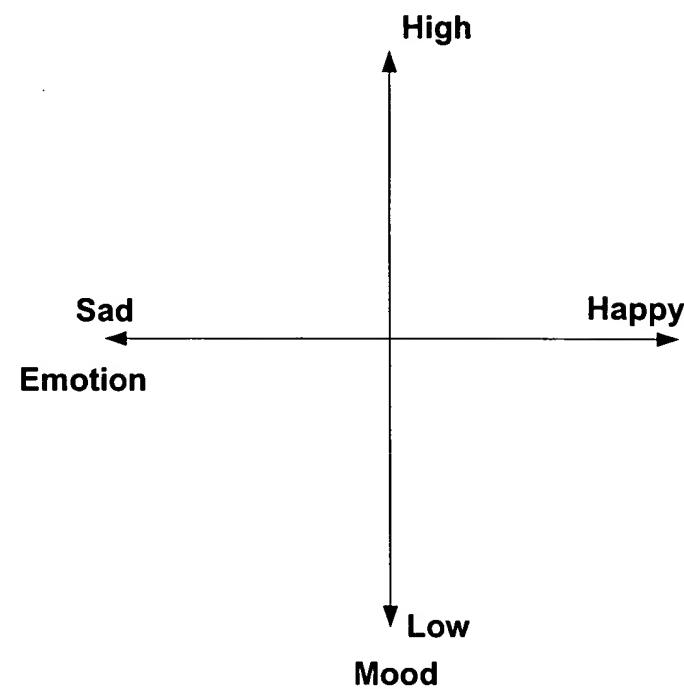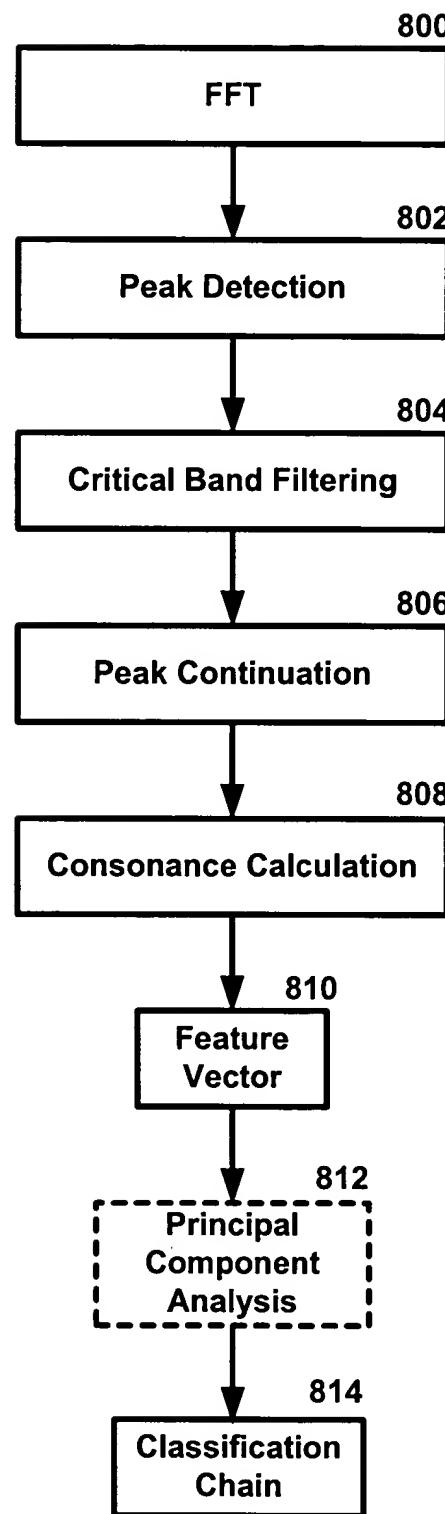Property Classification
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Fig. 10

Audio data in 16bit 44khz mono PCM format. **1020**

1030
Decimate data to common sampling rate, e.g. 43 Hz.

1040
Generate a data envelope that accentuates tempo characteristics while suppressing biases and trends.

1050
Generate 130 bins of data, where each bin is the "correlation strength" for the period defined by the bin number times 1/43.

1060
Feed into classification chain. For every calculated distance that is below a defined threshold, the corresponding classified tempo along with the distance is added to a table. The distance values in the table are translated into confidence values by taking $1/(distance^4)$. Each tempo value is divided by 10 and the log2 is taken. The integer portion is the "harmonic component" entry. The fractional portion is the "tempo component" entry.

1070
Tempo components are translated into vector representation. The range of 0 to 1 is mapped to 0 to 2pi. The sine and cosine of the angle are taken and multiplied by the corresponding confidence value. These sine and cosine components for the entire table are accumulated separately to create an overall representative vector. The angle of this vector is mapped back to a range of 0 to 1 to give an overall confidence of the tempo classification.

1080
The harmonic component of each table entry is evaluated. If the corresponding tempo component meets one of the following criteria, the harmonic is modified. If the tempo entry is less than the overall tempo classification - 0.5, the harmonic component entry is decremented. If the tempo entry is greater than the overall tempo classification + 0.5, the harmonic component is incremented. Each harmonic component table entry "votes" for its value with a weight proportional to the corresponding confidence value. The most prominent value is used as the overall harmonic component.

1090
The overall tempo is calculated by calculating $2^{(overall\ harmonic\ component\ +\ overall\ tempo\ component)}$ multiplied by 10.